NASA Partnerships and Collaborative Research on Ultra High Bypass Cycle Propulsion Concepts

Abstract

Current collaborative research with General Electric Aviation on Open Rotor propulsion as part of the Subsonic Fixed Wing Project Ultra High Bypass Engine Partnership Element is discussed. The Subsonic Fixed Wing Project goals are reviewed, as well as their relative technology level compared to previous NASA noise program goals. The current Open Rotor propulsion research activity at NASA and GE are discussed including the contributions each entity bring toward the research project, and technical plans and objectives.

NASA Partnerships and Collaborative Research on Ultra High Bypass Cycle Propulsion Concepts

Chris Hughes
SFW Ultra High Bypass Partnership Element Manager

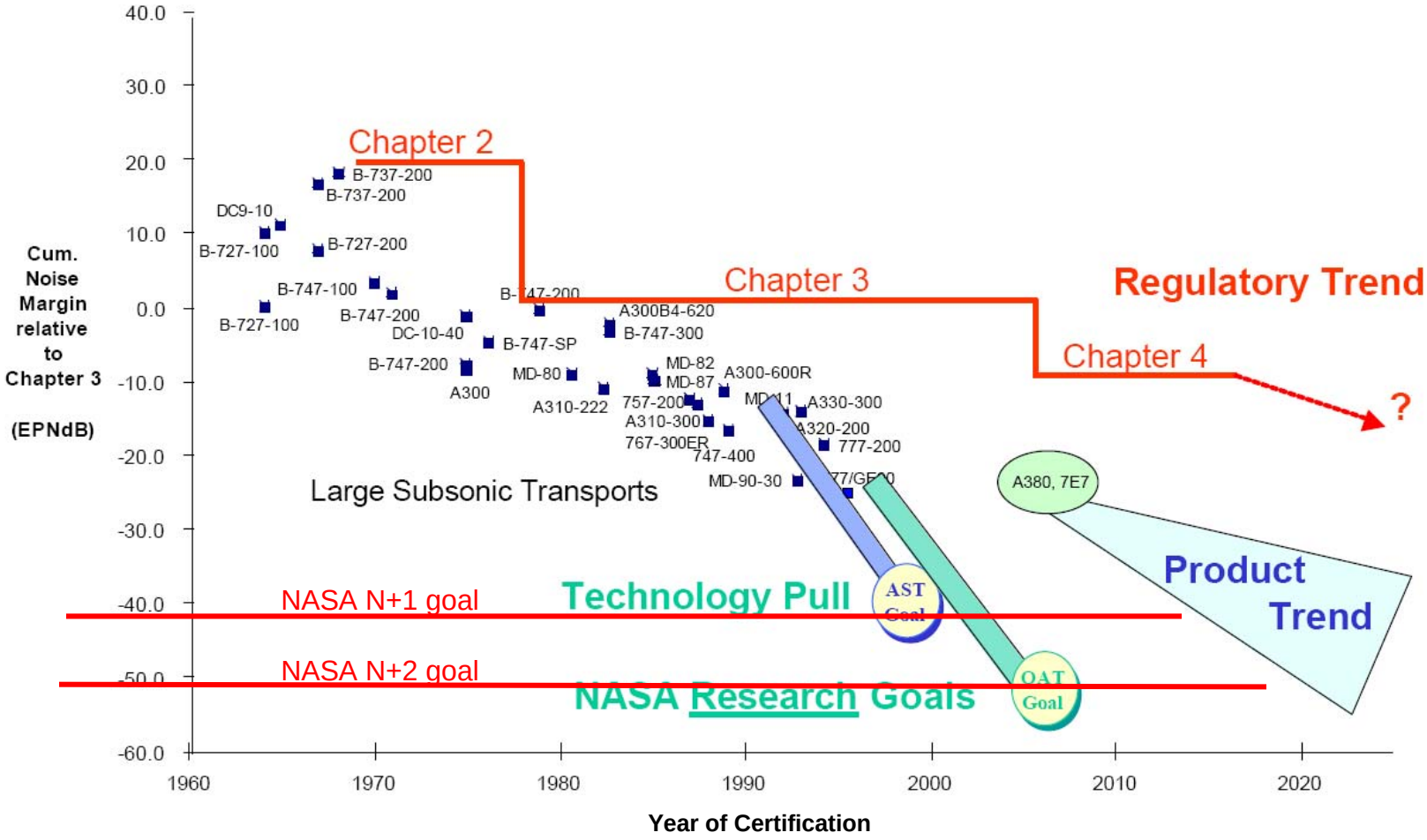
Fall Acoustics Technical Working Group Meeting
September 23-24, 2008

SFW UHB Partnership Element

- *Objective*
  - Develop noise reduction, emission reduction and performance improvement technologies for the Ultra High Bypass engine cycle, then demonstrate and validate their potential in full scale applications
- NASA has a strong and successful history of developing aircraft propulsion improvement technologies with Industry/OGA/Academia partners

SFW UHB Partnership Element

- *Environmental regulations, especially noise, continue to challenge new aircraft designs*



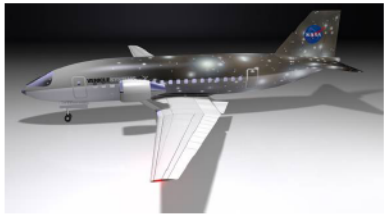
SFW UHB Partnership Element

- Today, increasing fuel prices along with aggressive SFW goals for "N + 1" aircraft requires refining and improving previous noise reduction and performance enhancing technologies, as well as demonstrating their combined effectiveness

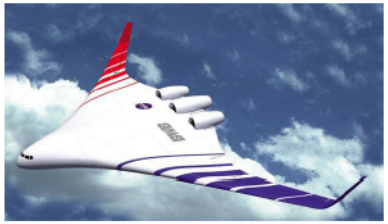
CORNERS OF THE TRADE SPACE	N+1 (2015 EIS) Generation Conventional Tube and Wing (relative to B737/CFM56)	N+2 (2020 IOC) Generation Unconventional Hybrid Wing Body (relative to B777/GE90)	N+3 (2030-2035 EIS) Generation Advanced Aircraft Concepts (relative to user defined reference)
Noise	- 32 dB (cum below Stage 4)	- 42 dB (cum below Stage 4)	55 LDN (dB) at average airport boundary
LTO NOx Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%**	-40%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metro-plex* concepts

** An additional reduction of 10 percent may be possible through improved operational capability
* Concepts that enable optimal use of runways at mutiple airports within the metropolitan areas
EIS = Entry Into Service; IOC = Initial Operating Capability

N+1 Conventional



N+2 Hybrid Wing/Body



N+3 Generation

?

However, *limited goals trading* is possible to address specific requirements

SFW UHB Partnership Element

➢ *Current UHB Partnerships*

- Pratt & Whitney
  - Collaborative turbofan research on Geared Fans concepts
  - Successful scale model aerodynamic and acoustic testing of isolated engine propulsor and half-span wing/nacelle model conducted in NASA wind tunnels completed in 2008
  - Ground demonstration of Geared Turbofan concept successfully completed May 2008
  - Alternative fuels test successfully completed on Geared Turbofan Engine Demonstrator using F-T fuel February 2008
  - Negotiations initiated for continued collaboration into next generation Geared Turbofan system studies in 2009

22" Geared Turbofan model test in Glenn 9'x15' Low Speed Wind Tunnel

PW Geared Turbofan Static Engine Demonstrator

SFW UHB Partnership Element

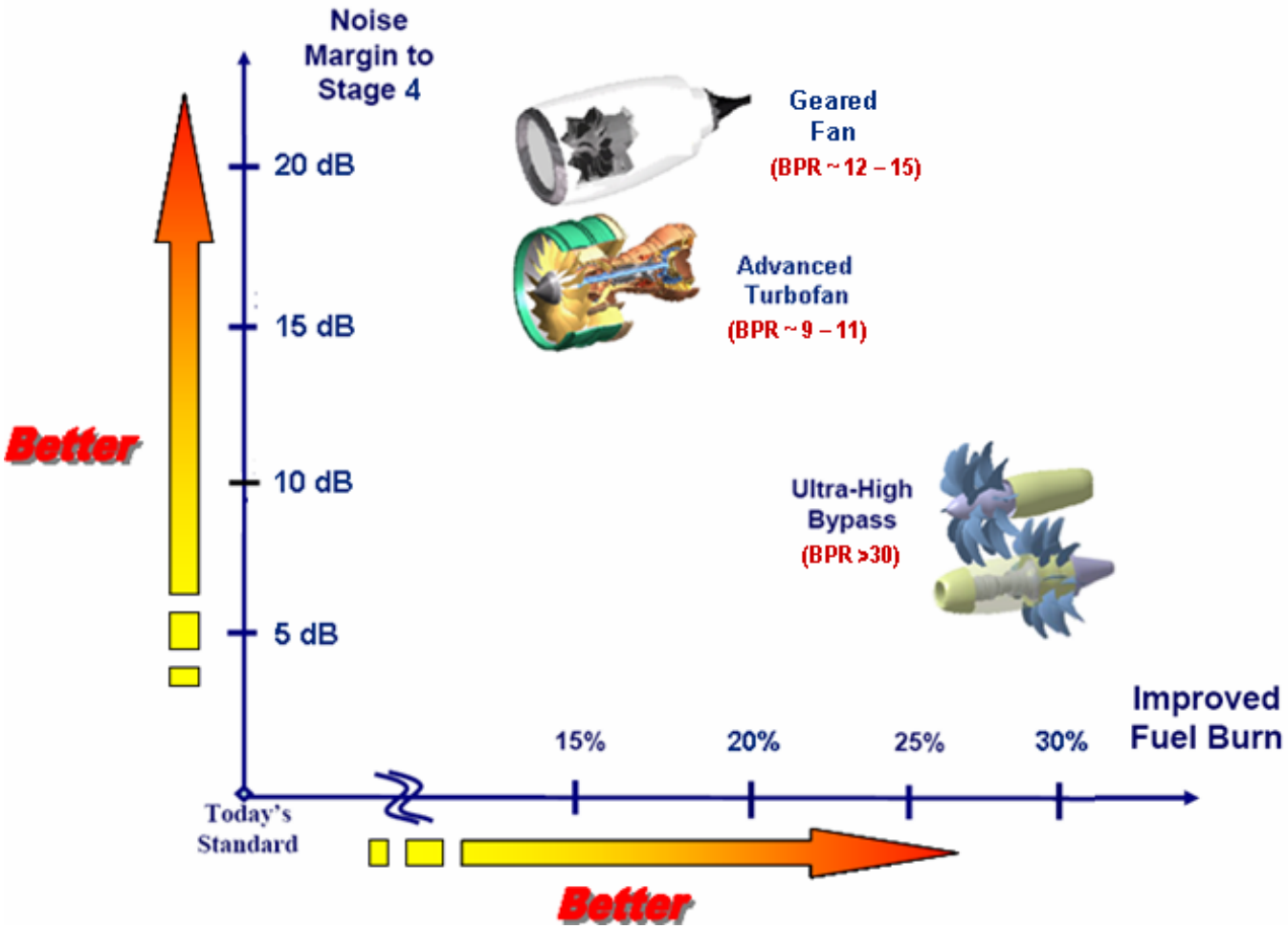
➢ *Current UHB Partnerships*

- GE Aviation
  - Space Act Agreement signed to initiate collaborative research into Open Rotor propulsion concepts
  - Initial concepts research to determine noise and performance characteristics be conducted in Glenn 9'x15' and 8'x6' wind tunnels starting in 2009

GE Aviation Open Rotor Propulsion System Concept

SFW UHB Partnership Element

- *Meeting SFW Project Goals Will Require Evaluating Game-Changing Architectures*
  - Open Rotor Technology has potential for significant performance improvement



SFW UHB Partnership Element

- *Open Rotor Technology has an immediate 10% better fuel burn potential … with challenges*
  - Noise - current acoustic goal of Stage 4 – 10 dB for configuration to get balanced solution for noise/fuel burn
  - Reliability – proven Entry into Service
  - Maintenance - costs need to be inline with current generation of turbofans
  - Installation- large effective fan diameter (12'–14') requires careful integration with airframe
  - Overall - determine best solution for meeting noise, fuel burn, maintenance and weight constraints

SFW UHB Partnership Element

- *Even greater potential performance and emissions improvements are possible ...*
  - Double digit SFC reductions
  - Improve fuel burn >30% compared to current standards
  - Reduce green house gases by 30%
  - Decrease fuel operating cost by 15%
- *... but significant technical challenges must be addressed*

SFW UHB Partnership Element

Leveraging the NASA / GE UDF® Experience

- Extensive 1980s collaborative testing experience of counter-rotation, open rotor concepts by NASA and GE

Climb/Cruise Testing in Glenn 8'x6' Wind Tunnel

Approach/Takeoff in Glenn 9'x15' Wind Tunnel

Installation Effects

Advanced Diagnostics

Counter-rotation Blade Profiles

- Fuel savings potentials up to 30% compared to turbofans were demonstrated

photos GE Aviation

SFW UHB Partnership Element

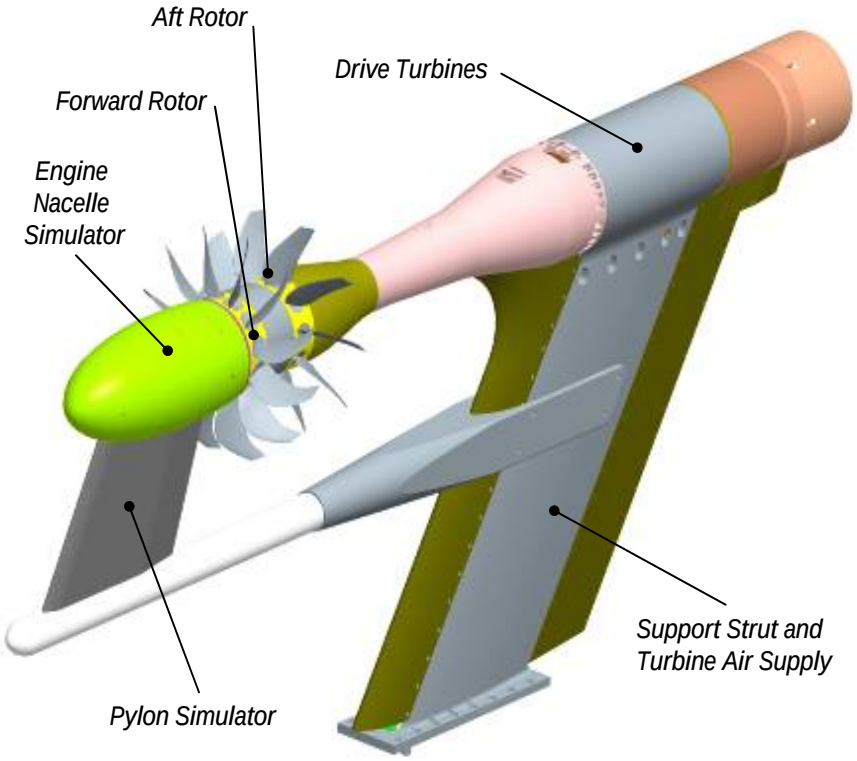
Leveraging the NASA / GE UDF® Experience

- Utilize extensive performance and acoustics experimental database of 1980s/1990s Open Rotor design configurations to guide new research activity
- Improved Computational Aeroacoustics developed by NASA/GE/Universities to evaluate new open rotor concepts
- Improved design and system analysis tools to screen potential candidates and minimize scale model test configurations
- Build on GE expertise in composite construction and advanced core technology to achieve full Open Rotor potential
- Utilize proven NASA test facilities, improved diagnostic testing techniques and existing scale model test articles

NASA / GE Partnership for the Open Rotor Test Program

➢ *Test Objectives*

- Produce shareable open rotor design and geometry to use as technology baseline
- Generate shareable database of aerodynamic/acoustic/aeroelastic test results to aid prediction code development and verification by Government/Industry/Academia
- Obtain Baseline Open Rotor noise for 2008 Advanced Design Technology
- Investigate installation and AOA effects on performance and noise across potential operating flight envelope

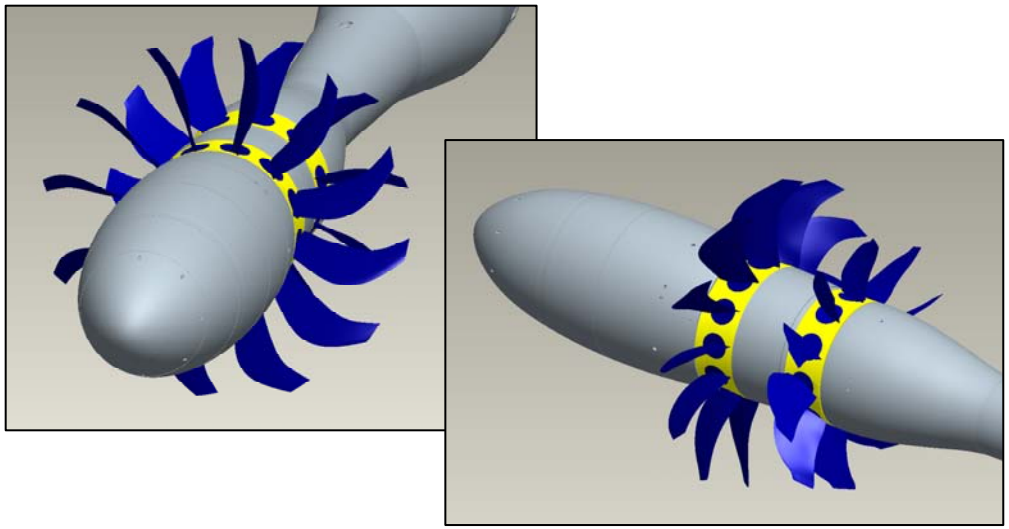


NASA Glenn Open Rotor Propulsion Rig

NASA / GE Partnership for the Open Rotor Test Program

➢ *Plan*

- NASA will provide updated, refurbished counter-rotation Open Rotor Propulsion Rig and systems
- GE will provide 1980s-based open rotor design and fabricate fan blades for testing



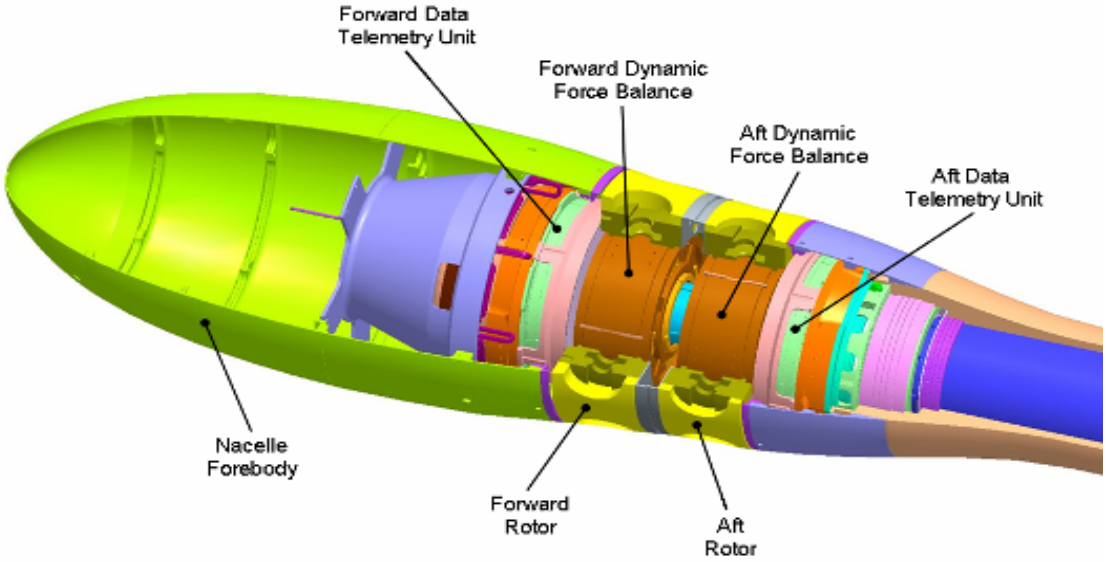
1980s Baseline Design Concept

- Performance, acoustics, flow diagnostics, and installation effects at low speed flight operations will be investigated in Glenn 9'x15' LSWT
- Performance and near-field acoustics at high speed flight operations will be investigated in Glenn 8'x6' SWT

SFW UHB Partnership Element

NASA / GE Partnership for the Open Rotor Test Program

- ***Glenn Open Rotor Propulsion Rig***
  - Two independently controlled, counter-rotating shafts
  - Each rotor capable of delivering up to 750 shp
  - Two component rotating force balances measure thrust and torque on each rotor, up to 400 lbs thrust and 500 ft-lbs torque
  - Up to 12 strain gages per rotor for blade dynamics
  - New digital telemetry units for each rotor transmit data from model to base system for transfer and storage on facility data system
  - All subsystems (speed control, lubrication, air supply) are new designs and fabrication



SFW UHB Partnership Element

➢ *Summary*

- Dramatically increasing fuel prices and aggressive environmental regulations are driving aerospace industry to re-investigate game-changing propulsion technologies
- Previous NASA and Industry research into very high efficiency propulsion proved that Open Rotor technology has the potential for significant performance gains
- Technological challenges remain to enable Open Rotor Propulsion a viable concept for aircraft propulsion – noise, maintainability, reliability, installation
- NASA and GE have extensive testing experience in open rotor propulsion through the NASA Advance Turboprop and GE UDF programs
- Collaboration through partnership will allow both NASA and GE to leverage their experience, expertise, facilities and resources to conduct research on advanced, Open Rotor Propulsion concepts